Abstract:

The objectives set within a manufacturing strategy clearly have a direct influence on shaping the direction and outcomes of a manufacturing system. So far, little is available to guide managers in translating a set of manufacturing objectives into actual implementation actions. This paper presents a three-stage framework to address this gap. The framework incorporates the Connectance Model and Analytic Hierarchy Process (AHP) as an interface between manufacturing objectives and strategy deployment. An example of how the framework can be used for capacity deployment is then provided.

Key Words: Strategy; Deployment; Manufacturing; Action; Connectance; AHP

Introduction

Strategy is a plan of actions to accomplish specific goals. The objectives set within a manufacturing strategy clearly have an influence on shaping the direction and outcomes of a manufacturing system. However, little is available to guide managers in translating a set of manufacturing objectives into actual implementation actions. Existing manufacturing strategy frameworks (Wheelwright, 1978; Fine & Hax, 1985; Hill, 1985; Platts, 1990) focus on broad direction and the establishment of manufacturing objectives, but are weak in translating these into action plans. Choices of action plans are difficult because the strategic priorities – cost, quality, delivery and flexibility are too highly aggregated to direct decision making. There are broad and generic categories with a multitude of possible interpretations (Garvin, 1993).

This paper describes a framework for strategy deployment which can assist managers in making good quality decisions during the process of strategy deployment. The framework incorporates the Connectance Model (Burbidge, 1984) and Analytic Hierarchy Process, AHP (Saaty, 1987) as an interface between manufacturing objectives and strategy deployment. The connectance model is used to map the range of possible action plans for a given objective, and then AHP is used to determine the most appropriate action based on an understanding of the existing manufacturing environment.

An overview of Manufacturing Strategy formulation process

A review of existing manufacturing strategy literature (Skinner, 1969; Hayes & Wheelwright, 1984; Fine & Hax, 1985; Hill, 1985; Platts, 1990) reveals two-stages of strategy formulation: setting the objectives; and objective deployment (see Figure 1).
Stage one is the setting of manufacturing objectives. These specify what the manufacturing system has to achieve. The manufacturing objectives must be consistent with the business objectives and take into account market needs, competitor performance, and internal strength and weaknesses.

Different terms can be found in the literature for the set of objectives that companies establish as the means for competing in the marketplace: competitive priorities (Hayes and Wheelwright, 1984), competitive criteria (Platts and Gregory, 1990), competitive variables (Marucheck et al., 1990), order winning criteria (Hill, 1989). A composite view of the literature (Leong et al., 1990) yields the following five manufacturing objectives: quality, delivery performance, cost, quality and innovativeness.

Stage two in the planning process is the objective deployment. These objectives need to be translated into prioritised action plans for further execution. The process involves identifying and evaluating the potential alternative actions which will achieve the desired objectives. The alternative actions include major kinds of decisions such as structural (capacity, facilities, technology, vertical integration) and infrastructural (quality, production planning, organisation, workforce policies, performance measurement) (Hayes and Wheelwright, 1984). This process usually requires a knowledge of manufacturing at several levels ranging from general manufacturing and management principles down to the details of the specific technology involved (Platts, 1990). The process is iterated until the most appropriate action plan is decided for successive implementation.

**Challenges**

The major impact of the existing strategy formulation approaches is very much at the setting of manufacturing objectives. The current strategy frameworks lack sufficient detail to indicate clearly how to deploy the objectives. Garvin (1993) points out that manufacturing objectives (cost, quality, delivery and flexibility) are often too highly aggregated to direct decision making. They are broad and generic categories with a multitude of possible interpretations. For example, quality can mean reliability, durability or aesthetic appeal.
While there has been much research into setting objectives the stage of objective deployment is often overlooked and poorly implemented (Anderson, et al., 1989; Swink & Way, 1995; Kim & Arnold, 1996).

For successful strategy deployment, a manager faces two challenges: to interpret and decompose the objectives to a form that is easy to understand; and to generate a range of feasible alternative plans.

How then can a factory manager identify a range of potential alternative actions that can be taken to achieve the given objectives? There are many ideas generation techniques like brainstorming, ideas mapping and lateral thinking, but these tools are more suitable for subject exploring and facilitating group discussion than providing a range of relevant alternatives.

Existing tools for strategy deployment are process oriented and lack detailed content which might assist a manager in identifying alternative action plans. There are some specific techniques, for example quality function deployment (QFD) and Honshin Kanri, but these are mainly directed towards objective definition rather than generating action plans. QFD is more directed for step by step customer needs deployment and is mainly used in the new product development process. Hoshin Kanri is useful for managing process changes and depends on objective decomposition based on the ‘catch ball’ concept.

Hence it is clear that a structured decision making process is needed to assist managers in approaching objective deployment. The process should incorporate tools that allow managers to have more complete information before a decision is made. In this paper, the concept of connectance model will be introduced.

**Connectance model**

The connectance model was developed in 1984 and is based on the premise that:

>‘Providing one does not attempt to specify relationships in quantitative terms, it is possible to make statements about system variable connectance, which are always true, but may not be relevant in all production situations’ (Burbidge, 1984)

The model contains a record of over 200 variables and shows how a given direction of change in each will induce a particular direction of change in any related variables. This model can form the basis of a tool for identifying alternative plans to meet the manufacturing objectives. This is better than conventional alternative generation techniques like brainstorming which depend heavily on intuition and personal experience. This model shows all the variable connectance and enables managers to get a comprehensive view of the variables interacting with the particular variable that they are studying. This helps them to determine a set of variables which they might modify and hence leads onto a set of improvement activities which they might undertake.

We have entered the 200+ variables into a computer database and developed a programme, using Visual Basic 6.0, to computerise the connectance model. The programme is very user friendly. Users are able to update or search the variable database easily. By linking to the database, the programme traces and displays the variable’s connectance network in hierarchy form. We also built in a connectance filter function based on level one to five, which allows the user to decide the level of connectance strength to be displayed. Other graphic interactivity features in the programme are sketching and node editing functions (size, colour, move, rename etc.) which enable the user to modify the network hierarchy display. The modified connectance network can then be transferred into a new database. In other words, the programme allows the user to evaluate and modify existing variable’s connectance and build a new connectance database from scratch.
A framework for manufacturing objective deployment

A framework which integrates the connectance model and AHP has been developed to approach manufacturing objective deployment (see Figure 2). The framework serves as interface between manufacturing objectives and strategy deployment. The framework is comprised of three stages: a) decomposition; b) alternative mapping and c) evaluation. Decomposition is the process of refining the manufacturing objectives into narrower categories and specifying the production variables that are likely to contribute to objective improvement. Alternative mapping is the process of determining a list of feasible improvement alternatives using connectance model to identify the variable connectance network. Evaluation is the process of using AHP carrying out pairwise comparison on the potential alternatives, to decide the ones that will be pursued further.

Stage 1: Decomposition

The first stage of the framework is to translate and more narrowly define the given objectives. When the objectives are more precisely defined, managers will be able to determine the production variables that have an effect and contribute to the achieving of given objectives. For example, if improved delivery is the objective, there are long lists of feasible options for achieving it. Managers will need to look into the current manufacturing situation and decide on which improvement perspectives such as production capacity, finished good inventory, lead time etc. that focus should be directed. Hence, if delivery is defined from the perspective of production capacity, then the manager will know capacity is the variable that need to focus on to improve delivery performance.

Stage 2: Alternative mapping

Once the objectives have been refined and the right variable has been targeted, the next step in the process is the development of a list of actions that might produce the desired results. Here, the
connectance model is used to determine the causal relationships of a particular variable being study. By using the programme developed for the connectance model, Figure 3 shows the weighted (4) connectance network output for the variable work center capacity (Cap-WC).

Once the connectance network has been identified, the managers need to prioritise the potential actions (alternatives) for further evaluation. For example, from the range of connectance network output pertaining to increase capacity, the manager may decide to take on machine set-up time, absenteeism, machine down time and production time for subsequent evaluation.

**Stage 3: Evaluation**

At stage 3, all the identified feasible alternatives must now be evaluated. This is a process that needs rigorous analysis and management insight. In the process managers must consider the ‘benefits’ or other concerns that each alternative offers. The Analytic Hierarchy Process, AHP method is used here for detailed pairwise evaluation of the alternatives.

The essential feature of the AHP is to enable a decision maker to structure a multiple attribute problem visually in the form of an attribute hierarchy. Application of AHP is based on following four principles (Saaty, 1994): decomposition; prioritization; synthesis and sensitivity analysis.

**Figure 3: Connectance network for work center capacity variable (weighted 4)**

For example, consider the problem of a manager who needs to decide among four work center capacity alternatives: (A1) set-up time, (A2) production time, (A3) absenteeism, and (A4) down time. Figure 4 shows how the manager may generate decision criteria by means of a hierarchical structure. At level 1, the focus is to improve capacity. Level 2 comprises the criteria/concerns that contribute to
improve capacity: operators, tooling, technicians, and working environment. Level 3 consists of the
four alternatives: $A_1$, $A_2$, $A_3$, and $A_4$.

To this end, the framework has shown how each objective should be first refined into narrower manageable scope; once the desirable variable has been identified, the connectance model is then used to determine the alternatives; and these alternatives are then evaluated with AHP. The final outcome will be the most appropriate alternative that will meet the given objective.

By utilising this framework, managers are able to take a large amount of feasible alternatives into consideration. Thus, they are able to make quality decisions with increased confidence in the outcome.

**Conclusion**

It is not easy for a manufacturing manager to approach manufacturing objectives deployment, this is because objectives are highly aggregated and have multitude of possible interpretation. We have presented a three stage framework which is being developed into a process to facilitate manufacturing objective deployment. The framework integrates connectance model to map out variable connectance network and AHP for comparing and evaluation of potential alternative action plans. On further work, a process to operationalise the framework will be developed and tested.

**References:**


